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(54) **DISHWASHER DOOR WITH COUNTERBALANCE ASSEMBLY**

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E05F 1/10	(2006.01)
A47L 15/42	(2006.01)
F24C 15/02	(2006.01)

(52) **U.S. Cl.**

CPC ***E05F 1/1075*** (2013.01); ***A47L 15/4261*** (2013.01); *E05Y 2201/638* (2013.01); *E05Y 2201/66* (2013.01); *E05Y 2201/668* (2013.01); *E05Y 2201/67* (2013.01); *E05Y 2900/312* (2013.01); *F24C 15/023* (2013.01)

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See application file for complete search history.

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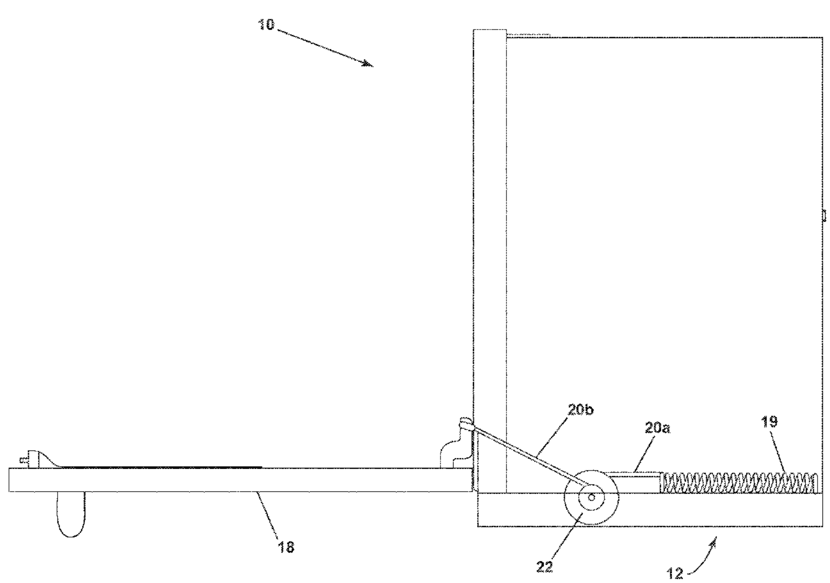
(57) **ABSTRACT**

A counterbalance assembly for an appliance has a guide member with a rotatable pulley with a fixed radius and a cam affixed to one side of the pulley and having a varying radius. The cam and the pulley rotate about a pulley axis of rotation as a single unit. The counterbalance has a force applicator that applies a counterbalance force to one of the pulley or cam, and the counterbalance has a connector that couples the other of the pulley or cam to the door. The counterbalance force applies a varying counterbalance torque to the door that is a function of the ratio between the fixed radius and the varying radius over the pivotal range of the door.

18 Claims, 5 Drawing Sheets



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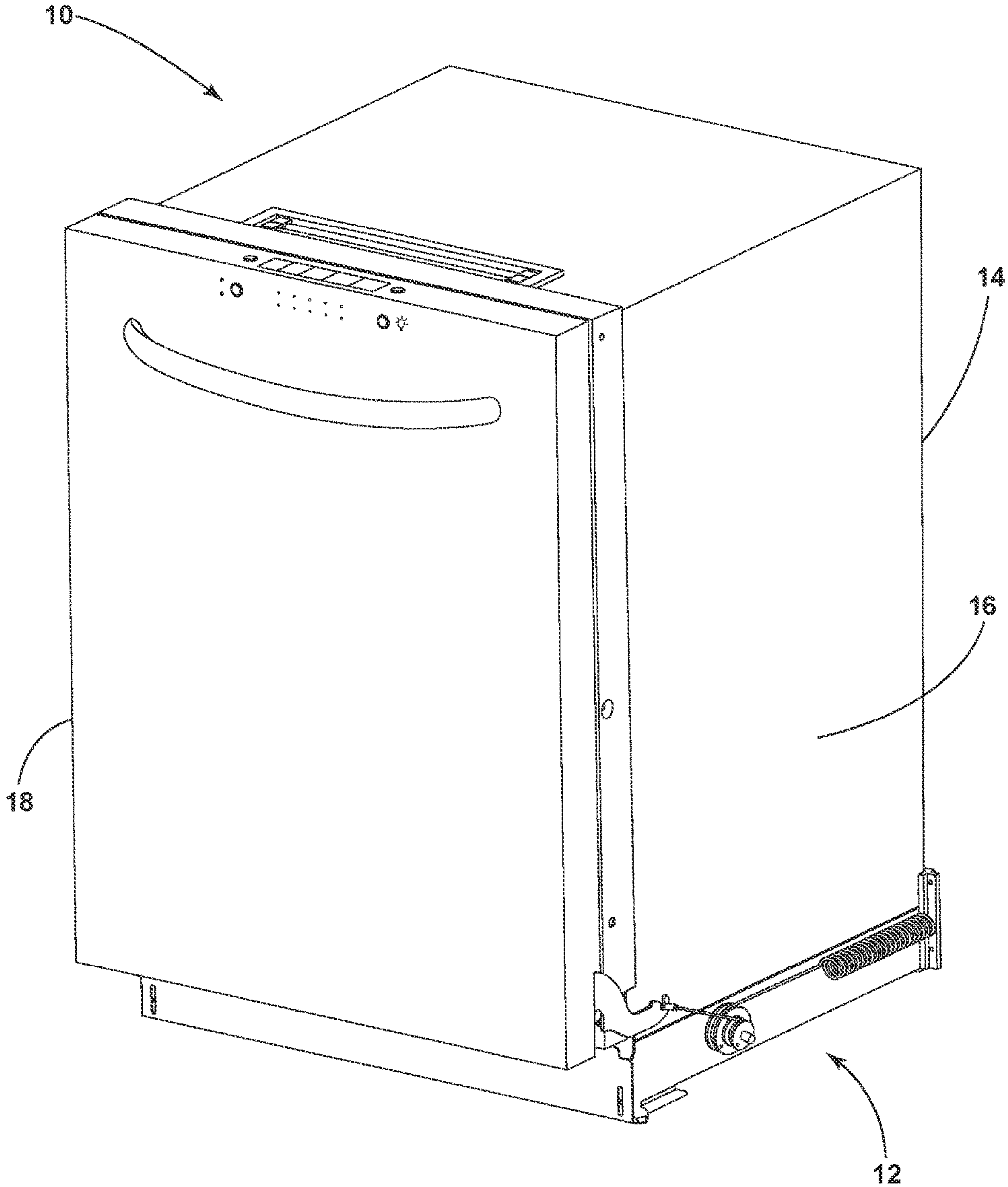

Fig. 1

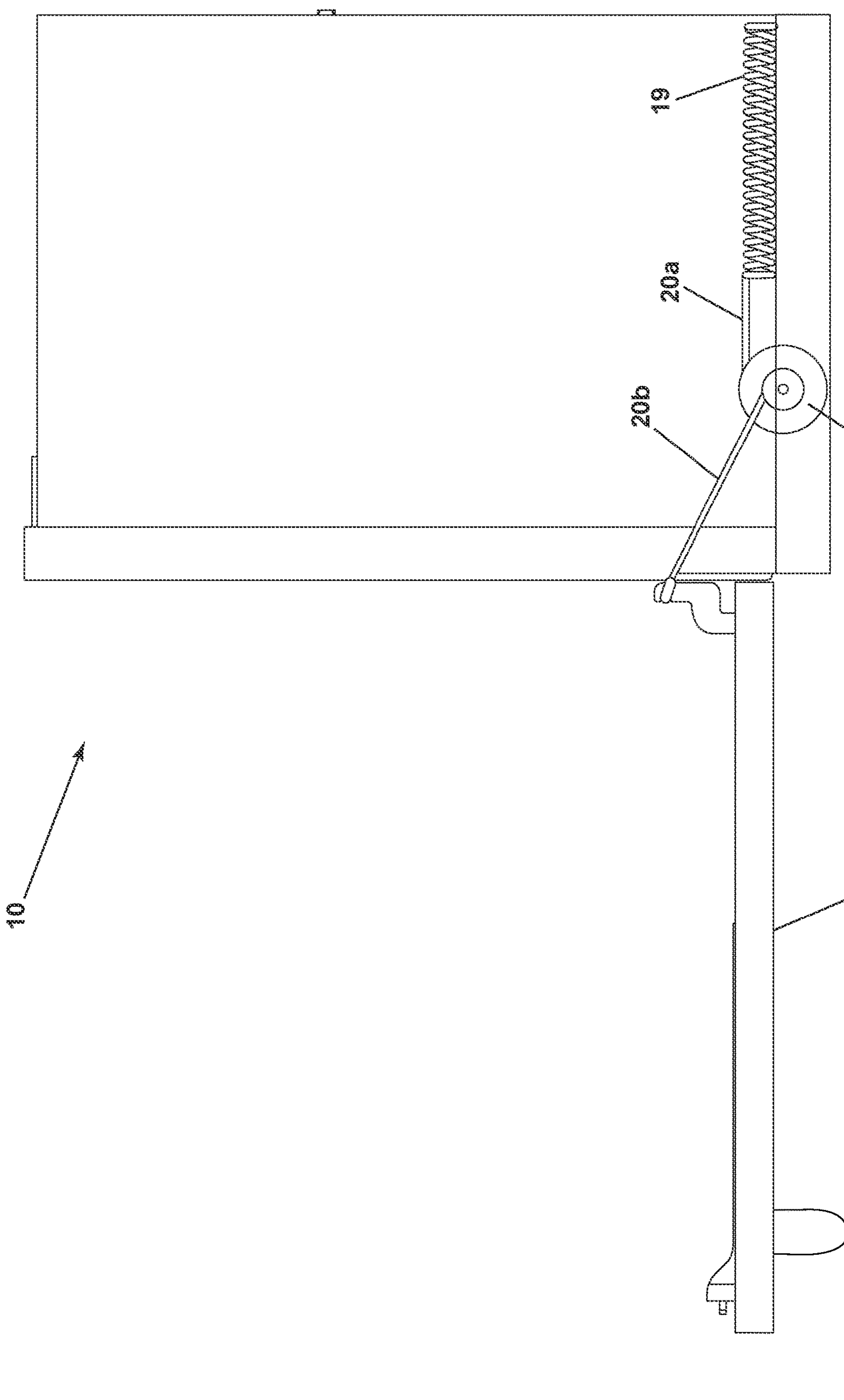

Fig. 2

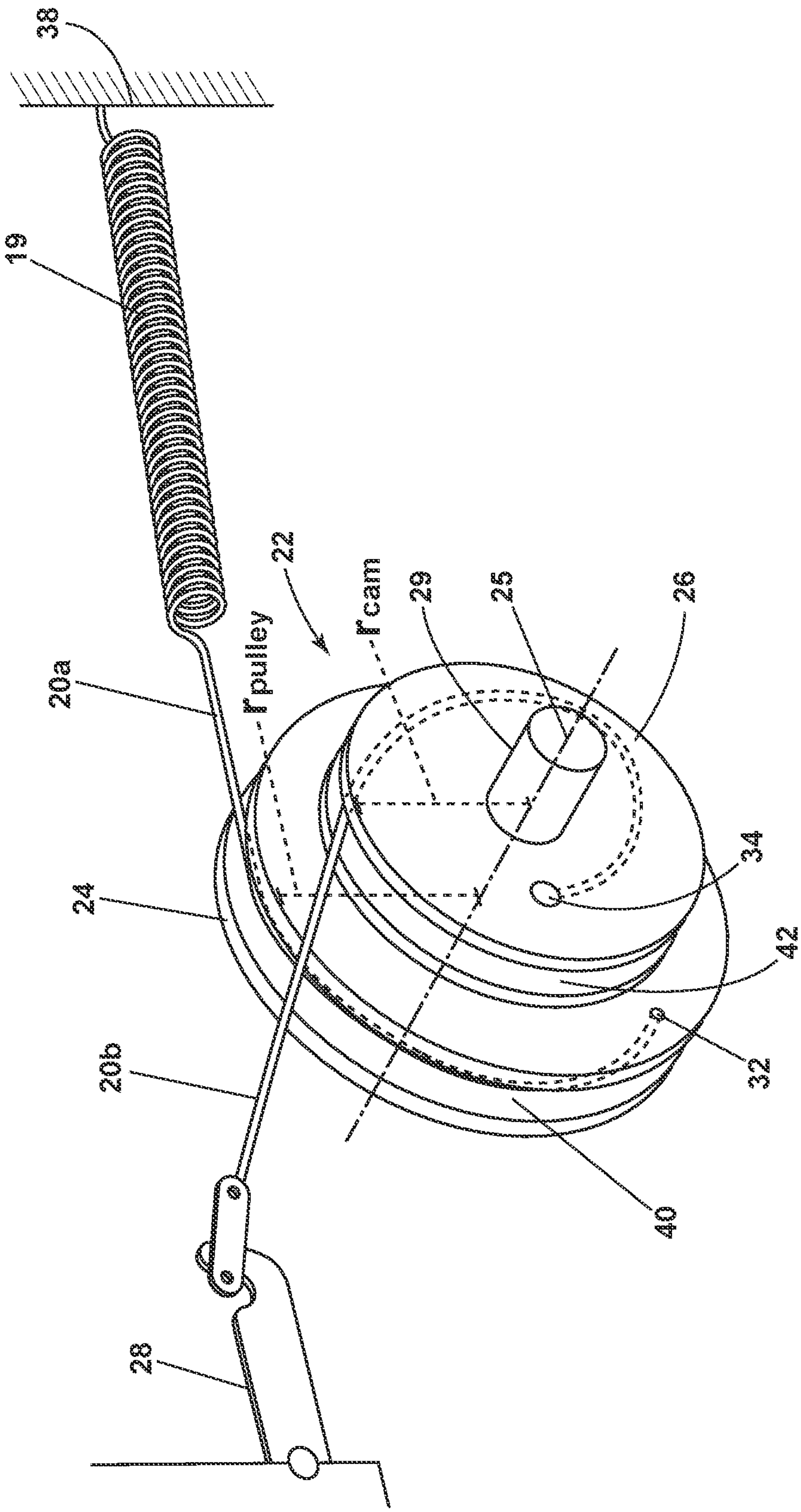

Fig. 3

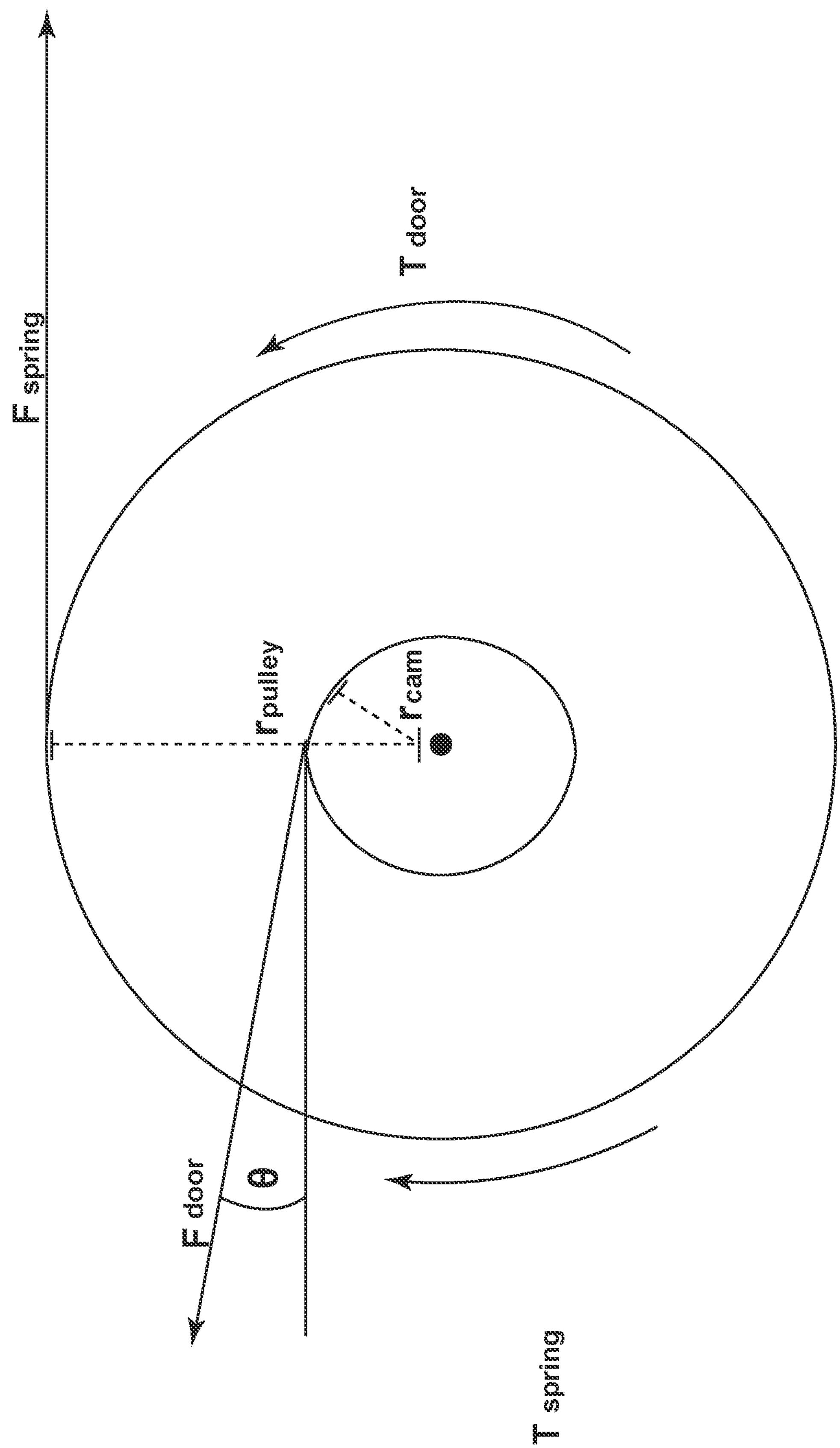

Fig. 4A

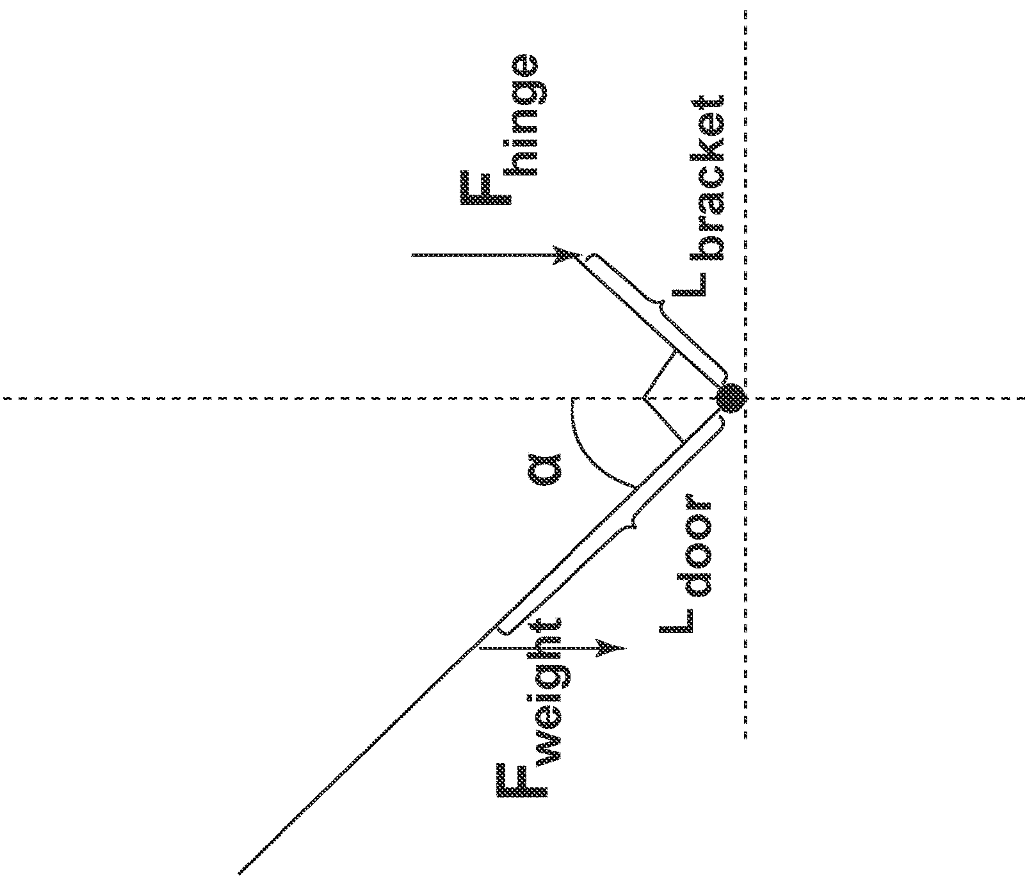

Fig. 4B

DISHWASHER DOOR WITH COUNTERBALANCE ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation application of U.S. patent application Ser. No. 16/838,134 filed on Apr. 2, 2020, now U.S. Pat. No. 11,230,867, which is a divisional of U.S. patent application Ser. No. 15/658,640, filed Jul. 25, 2017, now U.S. Pat. No. 10,655,376, and claims the benefit of U.S. Provisional Patent Application No. 62/372,836, filed Aug. 10, 2016, all of which are hereby incorporated by reference herein in their entirety.

BACKGROUND

A dishwasher typically includes a structural support system comprising a cabinet within which a washing chamber resides, wherein the cabinet defines a front opening. The front opening is configured to be engaged by a pivotally supported door used to close the opening. The door is typically hinged at the lower end such that the door can be opened by pivoting downward so as to permit access to the interior of the washing chamber. The dishwasher may include a device for balancing or counterbalancing the weight of the door, when opening and closing the door.

BRIEF SUMMARY

The present disclosure relates to a counterbalance assembly for an appliance comprising a cabinet defining an access opening and a door having a weight and hingedly mounted to the cabinet and pivotable about a door axis of rotation between a pivotal range between opened and closed positions to selectively open/close the access opening. The counterbalance assembly has a guide member with a rotatable pulley rotating about a pulley axis of rotation. The rotatable pulley has a fixed radius from the pulley axis of rotation and has a cam affixed to one side of the pulley. The cam has a varying radius from the pulley. The cam and the pulley rotate about the pulley axis of rotation as a single unit. A force applicator applies a counterbalance force to one of the pulley or cam. A connector couples the other of the pulley or cam to the door. The counterbalance force applies a varying counterbalance torque to the door that is a function of a ratio between the fixed radius and the varying radius over the pivotal range of the door.

The present disclosure also relates to a method of counterbalancing an appliance door pivotal about a range of rotation between an opened position and a closed position on an appliance cabinet. The method comprises applying a varying counterbalancing force to the appliance door throughout a range of rotation to effect at least two of true-hold, auto-close, or slow-open of the door.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view of a dishwasher with a counterbalance assembly.

FIG. **2** is a side view of the dishwasher in FIG. **1** with a door in opened position.

FIG. **3** is a perspective view of a counterbalance assembly having a guide member comprising a pulley and a cam.

FIG. **4***a* is a schematic representation of the guide member and showing the forces acting upon the pulley and cam.

FIG. **4***b* is a free body diagram of the forces acting on the pulley and cam of the guide member.

DETAILED DESCRIPTION

FIG. **1** shows a perspective view of a household appliance **10** of the type incorporating aspects of the current disclosure in the environment of a dishwashing machine. Although reference is made herein to a dishwasher **10**, it is understood that the counterbalance assembly **12** is adapted to be used with other devices where pivoting between a door and a body and is not necessarily limited to a dishwasher. For example, the counterbalance assembly **12** can be used with other home or kitchen appliances, such as an oven, a washer or dryer, or can be used outside the home appliance art.

The dishwasher **10** appliance shares many features of a conventional dishwasher, which will not be described in detail herein except as necessary for a complete understanding of the illustrative embodiment in accordance with the present disclosure. The dishwasher **10** includes a structural support system comprising a cabinet **14** within which a washing chamber **16** having an access opening is provided. A door **18** is pivotally mounted, typically by a hinge, to the cabinet **14** and pivots between opened and closed positions to selectively open/close the access opening of the washing chamber **16**. The door defines an arc relative to the door's axis of rotation and has a pivotal range between 0 and 90 degrees. The door is closed when it is at 0 degrees and open at 90 degrees. The pivotal range of the door can be further described to encompass three distinct portions: a first portion where the door is adjacent the open position, the arc of the door is generally between about 75 and 90 degrees, a second portion where the door is adjacent the closed position, the arc of the door is generally between about 0 and 15 degrees, and a third portion between the first and second portions, where the arc of the door is general between about 15 and 75 degrees.

A counterbalance assembly **12** is provided to counter the weight of the door **18** as it pivots through the operational range between the opened and closed positions. The counterbalance assembly **12** can be configured to counter, fully or partially, the weight of the door **18** through, all or part, of the door's operational range between the opened and closed positions. In this manner, the counterbalance assembly **12** can be configured to provide the same or different functionalities such as "hold" the door at any or all positions within the operational range, provide for an automatic closing of the door, or provide for a slow or damped opening of the door, to name a few. Although only one counterbalance assembly **12** is shown in FIG. **1** it is understood that there may be a counterbalance assembly **12** on both sides of the dishwasher **10**.

FIG. **2** shows the counterbalance assembly **12** comprising a force applicator such as a biasing member **19**, two connectors or flexible elements **20***a, b*, and a guide member **22**, which cooperate to enable the door **18** to be pivoted between opened and closed positions while providing the desired functionalities, such as a true-hold, automatic closing or auto-close, or slow-open, throughout the entire operational range, at predetermined sub-range(s) of the operational range, a discrete location(s), or any combination of these functionalities and locations. The connector or flexible element **20***a, b* can be in the form of a cord, such as a braided material or other elastic materials capable of maintaining tension.

FIG. **3** shows the detailed structure of the guide member **22** excerpted from the other parts of the counterbalance assembly **12**. The guide member **22** includes a rotatable pulley **24** and a cam **26** affixed to one side of the pulley **24** where both parts rotate about a common axis **25** as a single unit. The rotatable pulley **24** and cam **26** can be of independent pieces or a monolithic structure. The rotatable pulley **24** has a fixed radius, r_{pulley}, from the axis of rotation **25** while the cam **26** has a varying radius, r_{cam}, measured from the axis of rotation **25**. The rotatable pulley **24** and cam **26** can have respective guide tracks **40**, **42** located about their periphery and in which the flexible elements **20***a, b* are received. A coupling member **29**, which can be integrated to the cabinet **14** of the dishwasher **10**, extends outwardly to engage the guide member **22** at its axis of rotation **25** and mount the guide member **22** to the cabinet. The guide member **22** is rotatable about the coupling member **29** such that the coupling member **29** forms the rotation axis **25**.

The counterbalance assembly **12** includes a force applicator or biasing member **19**, such as a tension spring. One end of the biasing member **19** is attached directly or indirectly to the cabinet **14** such as by a bracket **38**, which may be an integrated part of the dishwasher cabinet **14**, The opposite end of the biasing member **19** is coupled to the first flexible element **20***a*. The opposite end of the first flexible element **20***a* is coupled to an anchor **32** integrated within the first guide tracks **40** of the pulley **24**. One end of a second flexible element **20***b* is coupled to a hinge bracket **28**. The opposite end of the second flexible element **20***b* is coupled to an anchor **34**, which can be integrated within the second guide tracks **42** of the cam **26**. The flexible element **20***a* is configured to extend at least partially about the pulley **24** within the guide tracks **40** to apply a clockwise (as seen in FIG. **3**) rotational force to the guide member **22**. The mechanics of the counterbalance assembly **12** will be described in detail with references to FIGS. **4***a* and **4***b*. It should be noted that the forces are described with respect to the clockwise/counter-clockwise directions as seen in FIGS. **4***a* and **4***b*. However, the referential directions (clockwise/counter-clockwise) are not limiting and are used for ease of description. Also, it should further be noted that frictional forces are present, but will be ignored for simplicity of the description.

FIG. **4***a* schematically identifies the forces acting upon the guide member **22** such as the tension between the biasing member **19** and the force from the weight of the door **18** that is transferred through the hinge bracket **28**. As the guide member **22** rotates about the axis **25**, these forces can be translated into clockwise and counter-clockwise forces or torques.

The clockwise torque and counter-clockwise torque can be expressed in the following equations respectively:

$$T_{spring}=F_{spring}\cdot r_{pulley} \quad (1)$$

$$T_{door}=F_{door}\cdot\cos(\theta)\cdot r_{calm} \quad (2)$$

Wherein the various terms show the respective following meanings:

T_{spring} is the clockwise torque provided by the tension of biasing member **19** through the flexible element **20***a*.

F_{spring} is the tension force of the biasing member **19**.

r_{pulley} is an all-around fixed radius of the rotatable pulley **24**.

T_{door} is the counter-clockwise torque provided by the opening force applied by the user and the weight of the door **18**.

F_{door} is the force transferred from the weight of the door **18** to the flexible element **20***b* through the hinge bracket when the door **18** is in opened position.

θ is the constant angle of elevation of the flexible element **20***b* from the horizontal plane.

r_{cam} is the varying radius of the cam **26** attached to the rotatable pulley.

For many of the functions achieved with the counter balance mechanism, it is helpful to knowing the equilibrium equation where the clockwise torque balances the counter-clockwise torque. When the torques are in equilibrium, the door will hold (i.e. true-hold), for example. When the torque from spring is greater than the torque from the door, the door will move toward the closed position (i.e. auto-close). When the torque from the door is greater than the torque from the spring, the door will move toward the opened position (i.e. slow-open).

A simplified version of the equilibrium equation can be derived by setting T_{spring} equal to T_{door} and solving the equation for the ratio of r_{cam}/r_{pulley}, which yields:

$$T_{spring}=T_{door}$$

$$F_{spring}\cdot r_{pulley}=F_{door}\cdot\cos(\theta)\cdot r_{cam}$$

$$r_{cam}/r_{pulley}=F_{spring}/F_{door}\cdot\cos(\theta) \quad (3)$$

As can be seen, the ratio of the radii, r_{cam} and r_{pulley}, can be selected to control the degree of equilibrium or imbalance between the torques, T_{door} and T_{spring}, to control the function of the door. As the torques, T_{door} and T_{spring}, are functions of the rotational position of the door and the force of the spring, and will vary with door position and spring extension, these varying forces can likewise be accounted for in the torques.

While it is possible to vary both radii, r_{cam} and r_{pulley}, to accomplish the desired function, it has been found sufficient to keep constant one of the radii while varying the other as needed to obtain the desired function. For purposes of this description, r_{pulley} is selected to remain constant while r_{cam} is varied, which results in the following equation:

$$r_{cam}=[F_{spring}\cdot r_{pulley}]/[F_{door}\cdot\cos(\theta)] \quad (4)$$

By varying the radius r_{cam}, the degree of balance or imbalance between the torques, T_{door} and T_{spring}, can be controlled over the operation range to achieve any of the desired functions of at least hold, slow open, and auto close.

Referring to FIG. **4**B, the equilibrium equation, in a more complex form, can be analyzed with respect to the angle, alpha, of the door with respect to the vertical. The counter clockwise rotational force F_{door} generated by the opening of the door **18** will be elaborated as a function of the door angle. The force F_{door} applied by the weight of the door **18** can be expressed in the following equation:

$$F_{door}=F_{hinge}/\sin(\theta) \quad (5)$$

As the door **18** and hinge bracket **28** may pivot about a hinge, the equilibrium torque between the weight of the door **18** relative to the hinge bracket **28** is expressed in the following equations:

$$F_{weight}\cdot L_{door}\cdot\sin(\alpha)=F_{hinge}\cdot L_{bracket}\cdot\cos(\alpha)$$

Making F_{hinge} as the subject of the equation:

$$F_{hinge}=(L_{door}/L_{bracket})\cdot F_{weight}\cdot\tan(\alpha) \quad (6)$$

Substituting equation (6) to equation (5), the force F_{door} applied by the weight of the door **18** can be expressed as a function of the door angle α in the following equation:

$$F_{door}=[(L_{door}/L_{bracket})\cdot F_{weight}\cdot\tan(\alpha)]/\sin(\theta) \quad (7)$$

Wherein the various terms show the respective following meanings:

F_{door} is the force transferred from the weight of the door **18** to the flexible element **20***b* through the hinge bracket when the door **18** is in opened position.

F_{hinge} is an upward vertical force of the hinge bracket created when the door pivots towards an opened position.

θ is the constant angle of elevation of the flexible element **20***b* from the horizontal plane.

F_{weight} is the force created by gravity acting on the center of mass of the door.

L_{door} is the length between the door pivot to the center of mass of the door.

α is the angle of door in opened position measured from the vertical axis.

$L_{bracket}$ is the length between the door pivot to the tip of the hinge bracket where it is connected to the flexible element **20***b*.

Substituting equation (7) into equation (2), the counter-clockwise torque acting upon the cam **26**, T_{door} can be expressed in the following equation:

$$T_{door}=(L_{door}/L_{bracket})\cdot F_{weight}\cdot r_{cam}\cdot(\tan(\alpha)/\tan(\theta)) \quad (8)$$

Referring to equations (1), (2), and (8), the equilibrium equation between the clockwise and counter-clockwise torques can be expressed in the following equations:

$$T_{spring}=T_{door}$$

$$F_{spring}\cdot r_{pulley}=(L_{door}/L_{bracket})\cdot F_{weight}\cdot r_{cam}\cdot(\tan(\alpha)/\tan(\theta)) \quad (9)$$

In order to create a counterbalancing function during the operational range of the door **18**, the disparity between clockwise torque and counterclockwise torque have to be maintained to accomplish the desired function. For example, to affect the slow-open function, the clockwise torque needs to be less than the counter-clockwise torque near the opened position. Put another way, the counterbalance force needs to be less than the torque attributable to the weight of the door so the door can move into the open position. The amount that the clockwise torque is less than the counter-clockwise force will control the rate at which the door moves to the opened position and can be selected based on the desired rate. A position holding or true-hold function of the door **18** can be achieved if the clockwise torque is substantially equal to the counter-clockwise torque at a given door angle. Or, in other words, the counterbalance force of the counterbalance assembly can offset the torque associated with the weight of the door to hold the door in position. The presence of frictional forces provide a margin such that the clockwise and counter-clockwise forces need not be exactly equal to provide the holding function.

Referring to equation (7), to create the slow-open function, the clockwise torque needs to be less than the counter-clockwise torque near the opened position as expressed in the following equations:

$$T_{spring}<T_{door}$$

$$F_{spring}\cdot r_{pulley}<(L_{door}/L_{bracket})\cdot F_{weight}\cdot r_{cam}\cdot(\tan(\alpha)/\tan(\theta)) \quad (10)$$

The reverse application of the above equations can be used to create an auto-close function where the counterbalance force of the counterbalance assembly **12** is greater than the torque attributable to the weight of the door so the door is automatically moved into the closed position. In this case, the clockwise torque is larger than the counter-clockwise torque and is expressed by the following equation:

$$T_{spring}>T_{door}$$

$$F_{spring}\cdot r_{pulley}>(L_{door}/L_{bracket})\cdot F_{weight}\cdot r_{cam}\cdot(\tan(\alpha)/\tan(\theta)) \quad (11)$$

Based on the same equations, to create the position holding or true-hold function of the door **18**, the clockwise torque must be substantially equal to the counter-clockwise torque at a given door angle α as expressed in the following equations:

$$T_{spring}=T_{door}$$

$$F_{spring}\cdot r_{pulley}=(L_{door}/L_{bracket})\cdot F_{weight}\cdot r_{cam}\cdot(\tan(\alpha)/\tan(\theta)) \quad (12)$$

Referring to equation (7), all the parameters will remain constant except for the dishwasher door angle, α which varies during the opening and closing of the door **18**. Unique to the present embodiment, the cam **26** is designed with varying radius r_{cam} from the axis of rotation **25** to create a counterbalancing function during the operational range of the door **18**. As shown in FIG. **4***a*, when the door **18** is moving towards an opened or closed position, α varies and a pull force $F_{counter}$ from the hinge bracket **28** was applied to the guide track **42** of the cam **26** through the flexible element **20***b*. This resulted in the controlled rotation of the guide member **22** while the biasing member **19** creates an opposite clockwise torque on the guide member **22**. As the guide member **22** rotates, the varying point of contact between the guide track **42** of the cam **26** and the flexible element **20***b* corresponds to a specific door angle, α. To create an equilibrium or disparity between the clockwise torque and counter-clockwise torque acting on the guide member **22**, the radius r_{cam} of the cam **26** is configured at each point of contact to adept to the changes in the door angle, α to create a specific counterbalancing function. Referring to equation (8), to create a slow opening function, the required radius of the cam **26** to maintain the condition where clockwise torque is lesser than the counter-clockwise torque can be expressed in the following equation:

$$r_{cam}<[F_{spring}\cdot r_{pulley}]/[F_{weight}\cdot(L_{door}/L_{bracket})\cdot(\tan(\alpha)/\tan(\theta))] \quad (13)$$

Referring to equation (9), to create an auto closing function, the required radius of the cam **26** to maintain the condition where clockwise torque is larger than the counter-clockwise torque can be expressed in the following equation:

$$r_{cam}>[F_{spring}\cdot r_{pulley}]/[F_{weight}\cdot(L_{door}/L_{bracket})\cdot(\tan(\alpha)/\tan(\theta))] \quad (14)$$

Referring to equation (10), to create a position holding function, the required radius of the cam **26** to maintain torque equilibrium at varying door angle α can be expressed in the following equation:

$$r_{cam}=[F_{spring}\cdot r_{pulley}]/[F_{weight}\cdot(L_{door}/L_{bracket})\cdot(\tan(\alpha)/\tan(\theta))] \quad (15)$$

The unique design in which the cam **26** is affixed to one side of the pulley **24** where both parts rotate about an axis **25** as a single unit allows for the adjustability of the cam **26** dimension during the manufacturing stage to meet several combinations of the above balancing functions.

It should be recognized that the door true-hold function, auto-close function, and slow-open function can be implemented across the pivotal range of the door. In addition, one or more of the functions can be implemented across various angles of the pivotal range. For example, the door can be implemented to be held in a true-hold position at any angle across the pivotal range or the when the door is between certain angles such as when the door is not adjacent the open or close position. In other words, when the door is adjacent the open position, the slow-open function can be implemented, or, when the door is adjacent the closed position, the auto-close function can be implemented, and true hold function can be implemented at angles in between.

Although the embodiment of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

I claim:

1. A counterbalance assembly for an appliance comprising a cabinet defining an access opening and a door having a weight and hingedly mounted to the cabinet and pivotable about a door axis of rotation between a pivotal range between opened and closed positions to selectively open/close the access opening, the counterbalance assembly comprising:

a guide member having a rotatable pulley rotating about a pulley axis of rotation and having a fixed radius from the pulley axis of rotation and a cam affixed to one side of the pulley and having a varying radius from the pulley; wherein the cam and the pulley rotate about the pulley axis of rotation as a single unit,

a force applicator applying a counterbalance force to one of the pulley or cam, and

a connector coupling the other of the pulley or cam to the door, wherein the counterbalance force applies a varying counterbalance torque to the door that is a function of a ratio between the fixed radius and the varying radius over the pivotal range of the door.

2. The counterbalance assembly of claim **1** wherein the door defines an arc relative to a door's axis of rotation and pivotal range of the door is between 0 degrees when the door is in the closed position and 90 degrees when the door is in the open position.

3. The counterbalance assembly of claim **2** wherein the pivotal range of the door further comprises a first portion adjacent the open position, a second portion adjacent the closed position, and a third portion between the first and second portions.

4. The counterbalance assembly of claim **3** wherein the first portion of the pivotal range of the door is between about 75 and 90 degrees, the second portion is between about 0 to about 15 degrees, and the third portion is between about 15 and 75 degrees.

5. The counterbalance assembly of claim **1** wherein the counterbalance force offsets the torque associated with the weight of the door to hold the door in position.

6. The counterbalance assembly of claim **5** wherein the counterbalance force offsets the torque associated with the weight of the door to hold the door in position at any angle over the pivotal range of the door.

7. The counterbalance assembly of claim **3** wherein the counterbalance force is greater than the torque attributable to the weight of the door and the door is automatically moved into the closed position.

8. The counterbalance assembly of claim **7** wherein the counterbalance force is greater than the torque attributable to the weight of the door and the door is automatically moved into the closed position when the door is in the second portion of the pivotal range and wherein the counterbalance force offsets the torque associated with the weight of the door to hold the door in position when the door is in the first or third portion of the pivotal range.

9. The counterbalance assembly of claim **3** wherein the counterbalance force is lesser than the torque attributable to the weight of the door and the door is automatically moved into the open position.

10. The counterbalance assembly of claim **9** wherein the counterbalance force is lesser than the torque attributable to the weight of the door and the door is automatically moved into the open position when the door is in the first portion of the pivotal range and wherein the counterbalance force offsets the torque associated with the weight of the door to hold the door in position when the door is in the second or third portion of the pivotal range.

11. The counterbalance assembly of claim **3** wherein the counterbalance force is lesser than the torque attributable to the weight of the door and the door is automatically moved into the open position when the door is in the first portion of the pivotal range and wherein the counterbalance force is greater than the torque attributable to the weight of the door and the door is automatically moved into the closed position when the door is in the second portion of the pivotal range and wherein the counterbalance force offsets the torque associated with the weight of the door to hold the door in position when the door is in the third portion of the pivotal range.

12. A method of counterbalancing an appliance door pivotal about a range of rotation between an opened position and a closed position on an appliance cabinet, the method comprising:

applying a varying counterbalancing force to the appliance door throughout a range of rotation to effect at least two of true-hold, auto-close, or slow-open of the door.

13. The method of claim **12** wherein the door defines an arc relative to the door's axis of rotation and the range of rotation of the door is between 0 degrees when the door is in the closed position and 90 degrees when the door is in the open position.

14. The method of claim **13** wherein the range of rotation the door further comprises a first portion adjacent the open position, a second portion adjacent the closed position, and a third portion between the first and second portions.

15. The method of claim **14** wherein the first portion of the range of rotation of the door is between about 75 and 90 degrees, the second portion is between about 0 to about 15 degrees, and the third portion is between about 15 and 75 degrees.

16. The method of claim **14** wherein true-hold occurs when the door is in one of the first or third portions of the range of rotation and the auto-close occurs when the door is in the second portion of the range of rotation.

17. The method of claim **14** wherein true-hold occurs when the door is in one of the second or third portions of the range of rotation and the slow-open occurs when the door is in the first portion of the range of rotation.

18. The method of claim **14** wherein the slow-open occurs when the door is in the first portion of the range of rotation, auto-close occurs when the door is in the second portion of the range of rotation, and true-hold occurs when the door is in the third portion of the range of rotation.

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